Chapter 13
Retention and Bladder-Emptying Disorders

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Background

Incomplete bladder emptying and urinary retention can cause a number of bothersome lower urinary tract symptoms including voiding symptoms (hesitancy, slow stream, incomplete emptying), storage symptoms (frequency, nocturia, incontinence, urgency), and urinary tract infections. In more severe cases of urinary retention and elevated bladder storage pressures, upper urinary tract decompensation can result. To properly understand the myriad of disorders that can cause urinary retention, it is important to have an understanding of the anatomy and voiding physiology. In essence, bladder-emptying disorders can result from bladder outlet obstruction, detrusor underactivity, or a combination of both.

In this review we aim to discuss the physiology of voiding and the pathophysiology and causes of incomplete emptying, to better define the difference between detrusor underactivity and bladder outlet dysfunction. We will also discuss algorithms for diagnosis and management of patients with incomplete emptying.

Physiology and Pathophysiology

Physiology of Voiding

Voiding physiology is complex and multifactorial with neurologic, endocrine, muscular, and cognitive components (Fig. 13.1). In its resting state, urine

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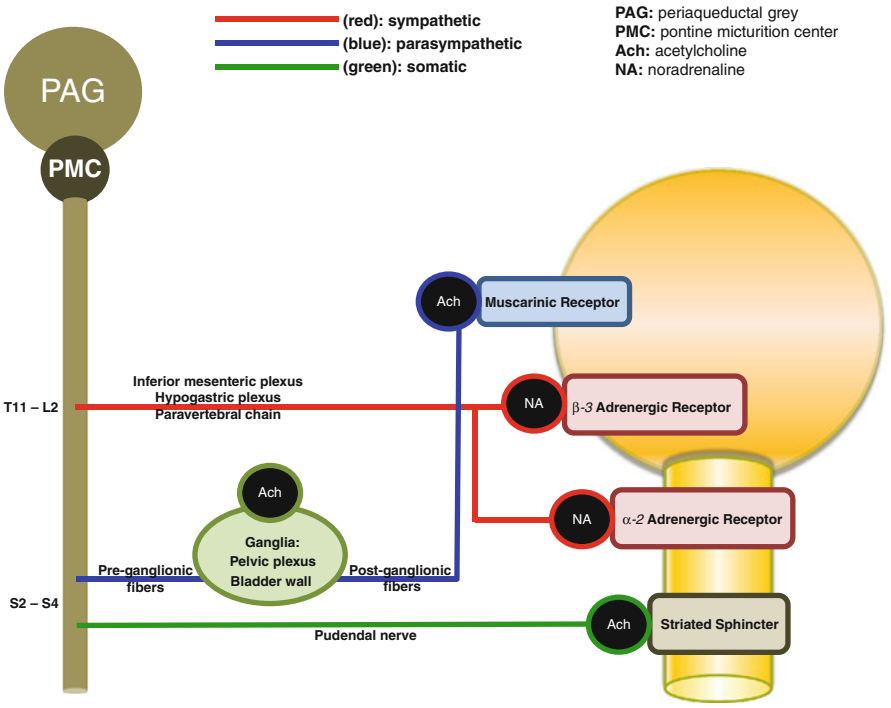

Fig. 13.1 Physiology of voiding

storage in mediated by the sympathetic nervous system, with stimulation of beta-3 adrenergic receptors that relax the bladder smooth muscle and the alpha-1 receptors to contract urethral smooth muscle. Somatic motor neurons travel through the pudendal nerve to innervate and maintain contraction of the external urethral sphincter striated muscle. Once there has been adequate filling, there is an increase in intensity of the afferent input via the pelvic nerves, which then stimulates the spinobulbospinal reflex pathway to activate the pontine micturition system. The parasympathetic system is thereby activated, reflexively inhibiting the sympathetic and somatic systems, resulting in relaxation of the outlet and stimulation of M3 muscarinic receptors to induce detrusor contraction. Additionally, there are other less studied cerebral pathways involving the periaqueductal gray matter and cognitive brain centers that influence sensation and voluntary voiding.

Ultimately, in order to properly empty, the bladder needs to generate a contraction strong enough to overcome the resistance of the outlet. Problems with this coordination, either caused by dysfunction of the bladder due to a reduction in the strength and/or duration of a detrusor contraction (detrusor underactivity), the outlet due to increased resistance or obstruction (bladder outlet obstruction), or both can cause incomplete bladder emptying.

Pathophysiology of Incomplete Bladder Emptying

Dysfunction of the outlet causing obstruction has been well studied. Chronic outlet obstruction has been associated with many changes to the morphology of the bladder, including changes to the extracellular matrix, electrical gap junctions, and smooth muscle enzymes and mitochondria. Obstruction has been shown to lead to a rapid hypertrophy of the bladder smooth muscle and an increase in collagenous connective tissue deposits, but with decreased myosin concentration, which ultimately results in a decreased force of contraction. It is theorized that obstruction results in acute ischemia, thereby affecting all components of the bladder that embody its viscoelastic properties (epithelium, connective tissue, vasculature, and smooth muscle), resulting in acute muscle dysfunction. The degree of dysfunction is thought to be related to the degree of tissue hypertrophy and not necessarily the duration of the obstruction. However, the bladder has amazing ability to regenerate and has shown evidence of recovery as early as fourteen days after obstruction.

Primary dysfunction of the bladder without obstruction, on the other hand, is not as well understood. A number of changes have been found to impact the bladder secondary to aging, ischemia, and comorbidities. Diabetic neuropathy has been shown to affect the innervation to the bladder, dull the sensory input, and induce changes to the physiology of detrusor smooth muscle. In cases of chronic overdistention, there can also be subsequent reversible or irreversible changes to the detrusor muscle cells. Studies focusing on the effect of aging on the bladder have demonstrated decreased ratios of detrusor muscle to collagen and changes in the quantity of muscle and collagen with aging.

A number of theories exist to try to explain the development of bothersome symptoms from incomplete bladder emptying. It has been postulated that the detrusor is organized into circumscribed modules controlled by a peripheral myovesical plexus, interstitial cells, and intramural ganglia. Bladder outlet obstruction may cause reduced blood flow, causing a transient or permanent ischemia that then affects sensitive nerve terminals and leads to denervation to certain modules. Supersensitivity then develops in the affected muscle modules, causing a reflexive excitation. Eventually the denervation progresses to an extent that the detrusor no longer functions and decompensates. These secondary changes that occur may explain why treatment will not always cause a resolution of symptoms. Other studies looking at smooth muscle proteins Connexin 43 and 26, the most predominant subtypes in the bladder, have found that increased fluid pressure from urine retention caused four- to fivefold increase in their levels, noticed as early at 7–9 h after obstruction. There have also been found to be increases in alpha-1 adrenergic receptor subtypes, particularly subtype alpha-1 d, now being identified as having a marked role in the development of irritative symptoms that are associated with bladder outlet obstruction.

Definitions Related to Urinary Retention and Bladder-Emptying Disorders

It is important to emphasize the value of having a common understanding of the terminology for purposes of reporting results and developing guidelines for treatment. The International Continence Society produced a report in 1988 to standardize definitions for a variety of lower urinary tract symptoms and conditions, which has subsequently been updated a number of times. Most recently in 2002 they published an updated report including urodynamic study findings. Appendix 1 reviews definitions from the report as they pertain to retention and bladder-emptying disorders.

"Lower urinary tract symptoms (LUTS)" now serves as a global term that applies to the variety of symptoms that may be representative of any bladder, urinary outlet, pelvic floor, endocrine, or neurologic abnormalities related to storage of urine and voiding. We are discovering that LUTS have a similar prevalence between men and women, and this prevalence increases in both groups with age. The EPIC study, a large multicenter survey study of 19,165 individuals 18 years or older in five countries using the 2002 ICS definitions for LUTS, found 64.3 % reported of at least one lower urinary tract symptom, with higher prevalence of storage symptoms in women compared to men (59.2 % vs. 51.3 %) and the opposite was true for voiding symptoms (men vs. women 25.7 % vs. 19.5 %). The overall presence of overactive bladder symptoms was 11.8 %, and the rate increased with age in both men and women.

Causes of Incomplete Bladder Emptying

Multiple potential sources contribute to incomplete bladder emptying (Fig. 13.2) and can be differentiated into dysfunction of the bladder or dysfunction of the bladder outlet.

The ICS 2002 defines detrusor underactivity (DU) as "a contraction of reduced strength and/or duration, resulting in prolonged bladder emptying and/or a failure to achieve complete bladder emptying within a normal time span." A movement toward the use of the term "detrusor underactivity (DU)" has been advocated to encompass this spectrum of diseases and to replace prior terminology used such as "impaired detrusor contractility," "underactive bladder," "detrusor areflexia," "hypotonic bladder," and "detrusor/bladder failure." Detrusor underactivity is impressed upon because it places the focus of the condition more on the symptoms rather than the etiology, which, as we will discuss, are broad and quite variable, resulting from neuropathic, myogenic, or pharmacologic sources. Currently there is not an accepted definition for the clinical syndrome associated with DU. It has been suggested that the term underactive bladder (UAB) syndrome could be applied to the "clinical syndrome that accompanies detrusor underactivity." The problem with this definition, as opposed to the overactive bladder syndrome (OAB), is that the symptoms associated with DU are variable and nonspecific. Osman et al. suggested that UAB

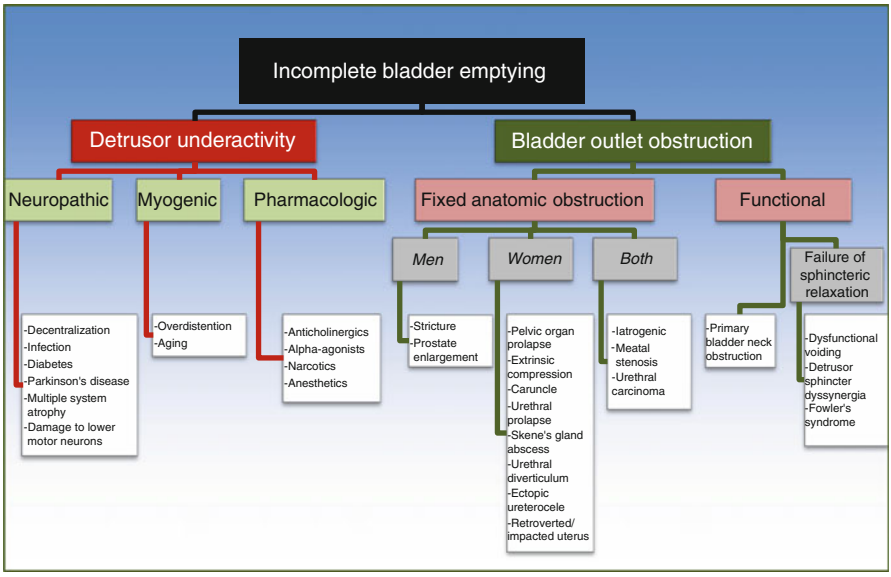

Fig. 13.2 Causes of incomplete bladder emptying

could be defined as "reduced sensation of the need to void (the opposite of urgency) that may be associated with frequency and nocturia or reduced voiding frequency often with a feeling of incomplete bladder emptying and incontinence that may predominate at nighttime." This definition has its obvious limitations.

Bladder outlet dysfunction, also coined as "bladder outlet obstruction (BOO)," may be a result of a fixed anatomic obstruction. Less obviously, it may be due to a functional abnormality in which no distinct structural abnormality is present, but rather the patient "functionally" has obstruction due to a neurological, myogenic, or psychological condition.

Detrusor Underactivity (DU)

Neuropathic Causes Medical conditions including diabetic neuropathy and infections with HIV, herpes simplex virus, tertiary syphilis, or post-infectious polyneuritis causing Guillain-Barre are known to be causes of impaired detrusor function from neurological dysfunction. Parkinson's disease is routinely found to cause detrusor overactivity but has been demonstrated to present with detrusor underactivity or acontractility. This has also been demonstrated in patients that suffer from upper motor neuron damage, particularly with hemorrhagic or cerebellar infarcts. Other spinal pathology primarily involving damage to lower motor neurons exiting from the lumbosacral vertebrae or sub-sacral lesions, such as from spinal cord injury, multiple sclerosis, trauma, or pelvic surgery, may result in detrusor underac-

tivity or areflexia or poor urethral sphincter function. Consideration should also be given to cases of disk herniation, spinal stenosis, myelodysplasia, and cranial or spinal arteriovenous malformations as possible contributors.

Myogenic Causes As discussed previously, it is postulated that ischemic detrusor denervation subsequently affects the entire myovesical plexus. The normal process of aging has also been associated with morphological changes to the detrusor muscle. Urodynamic studies have noted a loss of bladder contractility and voiding efficiency with increasing age. MRI imaging of the inula, the brain center that is responsible for processing visceral sensation, notes a diminished response to bladder filling in aging asymptomatic humans. In cases of chronic urinary retention, prolonged overdistention of the bladder results in changes to smooth muscle contractile function.

Pharmacologic Causes Pharmacological influences on voiding are known to be very powerful. Despite their use for lower urinary tract symptoms, antimuscarinics may be overly effective in inhibiting detrusor function, resulting in incomplete emptying. Other classes of medications that impact bladder emptying include narcotics and alpha-agonists (phenylephrine, pseudoephedrine, clonidine).

Numerous studies and case reports have found asymptomatic or symptomatic postoperative urinary retention (PUR) following administration of regional or general anesthesia. Soon et al. reported a rate of urinary retention of 39.3 % and UTI in 24 % of patients who underwent surgery for hip fracture, with higher risk associated in those with longer hospitalization and higher 2-year mortality. This may have significant implications for those that require hardware for their repairs. Another study utilizing bedside ultrasound in the post-anesthesia care unit (PACU) in patients that underwent thoracic, vascular, abdominal, ENT, or orthopedic surgery found 44 % of the patients had bladder volumes of greater than 500 mL. If treated within one to two hours, however, volumes of 500–1000 mL were not harmful. Similar studies have found incidences of PUR in the PACU of 16 %. Factors predictive of PUR include age greater than 50, intraoperative fluids greater than 750 mL, bladder volume of greater than 270 mL on entry to PACU, male gender, obstructive preoperative symptoms, spinal/epidural anesthesia, prolonged postoperative analgesia, and anesthesia time greater than two hours.

Childbirth has also been associated with overdistention and possible overdistention injury. A recent study evaluating 8000 consecutive births found a 0.05 % incidence of prolonged voiding dysfunction. It has also been suggested that labor exceeding 700 min increases the risk for postpartum voiding dysfunction.

In cases in which the bladder has acute distention for a prolonged period of time, defined as "a bladder filling volume at the time of diagnosis of at least 120 % of a normal bladder capacity, which has lasted at least 24 h," a new term has been introduced, "acute prolonged bladder overdistention" (ApBO), thought to be a consequence of spinal or epidural anesthesia, extensive pelvic or orthopedic surgery, or prolonged childbirth. It is often asymptomatic, leading to delayed treatment. ApBO differs from acute distention that is due to anatomic obstruction, which often initially is characterized by causing significant symptoms.

Bladder Outlet Obstruction (BOO)

Fixed Anatomic Obstruction Differing etiologies exist between men and women that may serve as an anatomic source of obstruction. In men, benign prostatic enlargement (BPE) causing benign prostatic obstruction (BPO) is the most common and well studied. Urethral strictures, although may develop in women, are far more common in men. They may be affiliated with a history of sexually transmitted disease, balanitis xerotica obliterans, trauma, or an iatrogenic cause such as urethral catheterization or transurethral surgery. Obstructive female urethral pathology may be due to urethral prolapse, diverticulum, or caruncle. Other possible causes of obstruction may include pelvic organ prolapse, Skene's gland abscess, a retroverted or impacted uterus during pregnancy, or extrinsic compression from, for example, a pelvic malignancy. Etiologies common to both genders include meatal stenosis, urethral carcinoma, or anti-incontinence surgery.

The latter is the most common cause of outlet obstruction in women. An estimated 2 % incidence of bladder outlet obstruction following surgery for stress urinary incontinence has been quoted in women based on data evaluating post-op urinary retention; however this may be an underestimation, as many women may have subclinical obstruction resulting in significant symptoms but no significant voiding dysfunction. Rates of voiding dysfunction, mainly obstruction, have been reported up to 33 % after autologous slings, 22 % after Burch, 20 % after retropubic, and 7 % and 4 % respectively for transvaginal needle suspension and tension-free vaginal tape. Suggested risk factors for postoperative obstruction include prior anti-incontinence surgery, concomitant pelvic organ prolapse, a lack of detrusor contraction on preoperative UDS, as well as a post-void residual greater than 100 mL and peak flow of less than 20 mL/s.

In men, a recent study of 117 patients that underwent artificial urinary sphincter (AUS) noted an increased incidence of postoperative urinary retention following transcorporal AUS placement. This was found in 32 % compared to 8 % of those that had a 4 cm or larger cuff placed in traditional fashion. Of those with a transcorporal AUS, 27 % versus 2 % of the traditional AUS underwent suprapubic tube placement. The overall urinary retention rate after AUS was 15 %. The mean duration of post-op catheterization was 6.5 days but lasted up to 6 weeks in some patients with suprapubic tube. They did report a lower rate of cuff erosion in those that had transcorporal cuff placement.

Functional Obstruction Functional causes of outlet dysfunction are as a result of a poorly relaxing outlet rather than a fixed anatomic obstruction, caused either at the level of the bladder neck or the urethra and pelvic floor.

Primary bladder neck obstruction (PBNO) is when the bladder neck fails to open adequately during voiding. The two requirements for this diagnosis are lack of anatomic obstruction and lack of increased striated sphincter activity. It was initially thought to be an entity diagnosed most commonly in men ages 21–50, but more recently there has been increasing recognition of this condition in women as well. There is minimal data on its prevalence in children. It has been hypothesized to be due to either failure of degradation of mesenchymal elements, with incorporation of connective tissue and subsequent smooth muscle hypertrophy, or underlying neurologic pathology.

Failure of the sphincter or pelvic floor to relax can be a result of three conditions. One cause is thought to develop as a habitual contraction of the pelvic floor and/or urethral sphincter during micturition, perhaps in young children who have pelvic floor discomfort (from possibly abuse or constipation) or as a response to urinary urgency. These patients are often diagnosed as having dysfunctional voiding, which is characterized by variable contractions throughout a void that prevent normal emptying. It is now being recognized as also developing in adults that present with a myriad of voiding complaints, thought to be a compensatory response to detrusor overactivity by urethral sphincter contraction throughout voiding that then becomes habit. Often patients with dysfunctional voiding present with very bothersome storage and voiding symptoms. If a patient has an underlying neurological condition (e.g., spinal cord injury, multiple sclerosis) and have the same symptoms and study findings, the patient will be diagnosed with detrusor sphincter dyssynergia (DSD). This can further be subclassified into lack of coordination by the external sphincter (detrusor external sphincter dyssynergia; DESD), which may occur by supracervical lesions, or by the internal sphincter (detrusor internal sphincter dyssynergia; DISD), which occur with lesions that occur at or above the takeoff of the sympathetic efferents at T11–L2 (Fig. 13.1). Additionally, the presence of DESD and DISD can coexist together.

Fowler's syndrome differs from dysfunctional voiding and DSD as patients are asymptomatic and are often in retention at time of diagnosis. It is a rare condition found in young women, typically postmenarche and in the second and third decades of life, with long-standing detrusor inhibition from a chronically non-relaxing external urethral sphincter. The original paper describing Fowler's syndrome in 1988 made an association to polycystic ovaries because 14 of the 22 patients with abnormal EMG activity had the condition, which thereby postulated a hormonal cause. There is poor data to support this as of yet.

Clinical Practice: Diagnosing Incomplete Bladder Emptying

The proper workup and evaluation of the patient is important to identify patients at risk, offer appropriate therapies in a timely fashion, and avoid unnecessary tests and treatments. Regardless of the etiology of incomplete emptying, the subsequent symptoms that develop may be debilitating despite very minimal objective findings, or the opposite may occur in which upper tract dysfunction is identified in a patient who has minimal to no symptoms. The goals of evaluation should be to establish a diagnosis, to define the characteristics of the patient's storage and emptying, and to identify patients at risk for long-term sequelae.

History

In addition to obtaining a routine history from the patient, one needs to take care to elicit additional information relevant to developing a differential diagnosis. A

clear elucidation of the nature, acuity, and duration of the urinary symptoms is crucial, whether they have storage symptoms (frequency, nocturia, urgency, or incontinence), voiding symptoms (slow stream, splitting of spraying of the stream, intermittency, hesitancy, straining, or terminal dribbling), or post-void symptoms (a sensation of incomplete emptying or post-void dribbling). A history of diabetes, stroke, infection, trauma, prior abdominal, back, or pelvic surgeries, prolonged anesthesia or childbirth, or abdominal or pelvic radiation history should be obtained. Additional information regarding any abnormal childhood voiding patterns and history of recurrent urinary tract infections (and associations to infection such as intercourse) are important to assess, as well as gastrointestinal symptoms of constipation, diarrhea, or fecal incontinence. Also important to gather is a sexual history, inquiring about a history of sexually transmitted diseases, dyspareunia, or a history of abuse. In women, a thorough gynecological history including pertinent history during deliveries, symptoms of prolapse, menopause, and prior gynecologic surgeries need to be ascertained. If a patient has been seen by other practitioners or had prior surgeries, it is very helpful to obtain reports on labs and imaging and prior operative notes. Finally, it is important to understand the patient's home situation and their functional status, as it may impact your treatment choices.

In patients who are not at risk of upper tract deterioration or recurrent urinary tract infections, the guiding force to management is going to be the degree of bother to the patient. A number of validated questionnaires are available to obtain an initial assessment and are also helpful to use through the course of management to assess for improvement or worsening of symptoms. Lepor et al. administered the American Urological Association Symptom Index (AUASI) survey to 750 men and women and found that aging men and women both have symptoms and rates of symptoms that are largely equivalent to each other, thereby suggesting that the AUASI is not BPH specific. It has also been found to be helpful in assessing lower urinary tract symptoms in women independent of incontinence.

Physical Exam

In addition to performing a routine physical exam, particular attention should be paid to particular aspects of the exam. A palpable or percussible bladder during the abdominal exam is important to gauge. The back should be examined for vertebral pathology or costovertebral angle tenderness. Hard stools, fecal impaction, masses, and anal sphincter tone need to be assessed during the rectal exam. A thorough neurological exam and an assessment for lower extremity edema should be noted. The meatus should be noted for abnormalities. In men, palpation of the penis for plaques or masses and examination of the prostate to ascertain size or for tenderness or masses are important. In women, assessment for pelvic organ prolapse, for pain during palpation of the levator complex, or for urethral or vaginal masses that may be suggestive of a cyst, abscess, or diverticulum is warranted.

Diagnostics

A number of studies can be utilized in the assessment of the patient. The information gained from the history and physical should help to guide the practitioner to what studies should be ordered, so as to avoid a potentially unnecessarily costly and invasive workup. However in certain patients, of primary concern should be the assessment of risk, which includes upper tract deterioration or development of urinary tract infections.

Post-void Residual (PVR) A post-void residual will be the first test that indicates urinary retention. It can be performed with a bedside bladder scan or ultrasound, or if those are unavailable or it is unclear if it is accurate, a catheterization may be necessary. Portable ultrasonographic devices have been found to be largely comparable to catheterization.

No value for PVR has been established as defining abnormal bladder emptying. A range of values have been quoted for men as considered incomplete bladder emptying, including 150 mL, 200 mL, or 300 mL. Abrams et al. cited that PVRs of 300 cc are the lowest threshold after which the bladder becomes suprapubically palpable based on urodynamic findings. The UK National Institute for Health and Clinical Excellence proposed using a PVR of greater than one liter. AURO.it (Italian Association of Urologists) Guidelines for BPH define a pathological PVR "more than one-third of total bladder capacity." A combination of these criteria proposed by Negro et al. suggests using a PVR of >300 mL in those who can void and a PVR of >1000 mL in those who are unable to void.

For women, the literature most often quotes a PVR of >100 mL to be "elevated." One study using these criteria in urogynecology clinic found a PVR in those with urgency and frequency without incontinence was 5 % and 10 % and in those with urgency incontinence an overall incidence of 9 %. Another study utilizing a post-void residual of 100 mL or greater in women with symptoms of urgency, frequency, and urgency incontinence found 19 % of patients to have elevated PVR; risks were increased in older age, prior incontinence surgery, history of multiple sclerosis, greater AUASI, vaginal parity greater than 2, greater pad use, and stage 2 or greater vaginal prolapse.

It is important to interpret post-void residual data in the context of the patients symptoms and, when available, urodynamic findings. For example, an "elevated" post-void residual in a patient with poor or decreased compliance likely has more clinical significance than the same PVR in a patient with a compliant bladder.

Uroflow A uroflow helps to gather information on flow rates, time to void, and presence of abdominal straining with voiding. The voided volume added to the post-void residual may be indicative of a large capacity bladder but may not be accurate if the patient is not at capacity when they void. Maximum flow rates are helpful and will be discussed in greater detail when used in the setting of urodynamic evaluation.

Labs A urine dipstick may help to evaluate for a urinary tract infection. In patients that have concern for a urine infection, either because of the dipstick findings or

symptoms, a urine sample should be sent for urinalysis and/or culture. Assessment for proteinuria may also be performed. Patients that have concern for upper tract dysfunction should have a basic metabolic panel in order to check serum creatinine, electrolytes, and GFR.

Imaging Upper tract imaging is important in those with a significantly elevated post-void residual or concern for upper tract dysfunction. A renal and bladder ultrasound may assess for hydronephroureterosis. It may also be able to identify bladder stones and for thinning of renal parenchyma. The same information may be obtained from a non-contrast CT scan, but a US does not expose the patient to radiation, and can measure ureteral jets and a post-void residual. A contrast CT will not provide additional information in regard incomplete emptying and should not be performed in those with renal dysfunction. An MRI is helpful in cases of pelvic and urethral pathology in women, such as to assess for urethral diverticulum. In addition to identifying urethral pathology, it is helpful to assess extrinsic factors as well, such as Mullerian duct remnants or leiomyoma. A dynamic MRI may also help assess degree of prolapse but is an expensive study that may not provide any additional information about bladder emptying than less expensive studies. Patients on dialysis should not receive gadolinium due to the risk of nephrogenic systemic fibrosis.

Cystourethroscopy Cystoscopy in and of itself does not make a diagnosis of obstruction but can help to determine the cause or anatomy of the obstruction. Indications for cystoscopy include evaluation for any masses or lesions that may be a source of symptoms in patients with a risk of malignancy or for those that also endorse gross hematuria. In those with concern for stricture, this allows evaluation of the urethra. The prostate can also be grossly assessed for obstructing lobes or prominent median lobes. Those that have had prior surgery on the bladder, urethra, or prostate can be assessed for scarring or obstructing masses. It allows the practitioner the ability to visually assess for urethral angulation and distention ability and assess for anatomical variants (diverticuli or masses) or foreign bodies.

Urodynamics The definitive study to evaluate for the cause of incomplete bladder emptying is urodynamics. A vast amount of information can be obtained from the study, including presence or absence of sensation, capacity, compliance, involuntary contractions, generation of detrusor pressures, storage pressures, urinary flow rates, and post-void residual. It is important to remember that discomfort or anxiety during the exam may impair the results. If feasible, there may be a role for ambulatory urodynamics to try to assuage this issue. Urodynamics is not perfect, however, as there may be a number of variables that affect the study, including catheter size or test anxiety; however it is the best study available to evaluate for detrusor contractile dysfunction with simultaneous pressure-flow analysis and quantify the degree of obstruction.

Fluoroscopy at the time of urodynamics can be exceedingly helpful in identifying obstruction and at what level it exists, particularly in women. This is particularly helpful when trying to differentiate between functional causes of bladder outlet obstruction. In primary bladder neck obstruction, the obstruction is at the

bladder neck, while in dysfunctional voiding or detrusor external sphincter dyssynergia, the obstruction is at the external sphincter and may reveal a "spin top" urethra. We have found fluoroscopy to be the best identifier for obstruction independent of max flow and detrusor pressures. Additionally, the presence and grade of vesicoureteral reflux can be assessed, as well as any abnormalities of the bladder (diverticulum, trabeculations, or filling defects) and urethra (stricture or diverticulum).

Voiding Cystourethrogram Even in the absence of multichannel urodynamics, the fluoroscopic images obtained from a voiding cystourethrogram can provide a large amount of information, namely, for the level of obstruction, the presence of vesicoureteral reflux, or anatomic bladder or urethral abnormalities.

Nomogram Over the past decade, a number of nomograms have been developed to define obstruction; however their application is largely for the evaluation of men. In 1997, the International Continence Society published a nomogram recommended for use in older men with obstructive LUTS based on the results of studies from the Abrams-Griffiths and Schafer nomograms which was coined the "provisional ICS method for definition of obstruction." Utilizing the Bladder Outlet Obstruction Index (BOOI) from the Abrams-Griffiths nomogram, measured by the equation BOOI = Pdet @ Qmax – 2(Qmax), men are divided into three groups: obstructed if BOOI >40, equivocal if BOOI 20–40, and unobstructed if BOOI <20. The bladder contractility index (BCI) is derived from the Schaefer nomogram and is calculated by the formula BCI = PdetQmax + 5(Qmax) and defines contractility as strong if >150, normal if 100–150, and weak if <100.

Women do not yet have clearly defined urodynamic criteria that may be indicative of obstruction, likely because the prevalence and causes of obstruction are quite different. Variable criteria have been suggested for women, including peak flows of less than 12 mL/s, as well as values for detrusor pressure at peak flows of greater than 20cmH_2O to greater than 50cmH_2O. The Blaivas-Groutz nomogram defines obstruction as those that have a maximum flow rate less than 12 mL/s, with our without radiographic evidence of obstruction, in the presence of a sustained detrusor contraction greater than 20 cmH_2O, and/or an inability to void. It has been shown, however, to overestimate the prevalence of obstruction in women. Utilizing variants of these criteria, Choi et al. evaluated lower urinary tract symptoms in women and defined "voiding difficulty" at a Qmax less than or equal to 15 mL/s. If on urodynamics the detrusor pressure at peak flow was >20 cmH_2O, they were subclassified as having bladder outlet obstruction, and if it was <20 cmH_2O, it was defined as detrusor underactivity. Using this criteria, of 1415 women that presented to urology offices, 102 (12.8 %) complained of voiding difficulties and had peak flows under 15 mL/s. Of these, 89 women (87.2 %) showed bladder outlet obstruction, and 13 (12.8 %) showed detrusor underactivity. We have found that pressure flow dynamics in obstructed women are quite variable and the diagnosis requires an individualized rather than a nomogramic approach. That is why we favor the videourodynamics criteria.

Clinical Practice: Treatments and Techniques

Treatment of the patient should be driven by two factors: risk and symptoms. The following figure categorizes the approach to the patient with concern for incomplete bladder emptying and should be considered when determining the aggressiveness of the workup and treatment for the patient (Fig. 13.3). Initial assessment should be approached with a history, a physical exam, and an evaluation of a post-void residual (PVR). As discussed, a set value for an acceptable post-void residual is still undetermined. Based on various prior recommendations and guidelines, one may consider cutoff values of 300 mL in men and 100 mL in women as limits for elevated post-void residual; however this will be based on the patient, their comorbidities, and the practitioner's judgment. Any patient with risk of additional problems including upper tract deterioration or recurrent urinary tract infections should be strongly advised to undergo some treatment to drain the bladder. Those without risk can then be further stratified by degree of bother and offered treatment based on the cause of their incomplete emptying.

Once a patient has been classified into a risk and symptom category, an appropriate workup can be initiated to determine the cause. The treatments will vary depending on the cause. For those that are unbothered and not in any risk, they should be offered an option to do no therapies and monitor them biannually to annually. Conservative therapies include double or triple voiding, intermittent catheterization, or indwelling catheterization. These may also be employed in those with significant comorbidities that may make them poor surgical candidates or that refuse invasive therapies.

Bladder Dysfunction

Unfortunately, most causes of bladder dysfunction are irreversible, particularly neuropathic and myogenic causes. Early intervention and optimal management of neurological disorders may help to delay detrusor dysfunction, but ultimately it may

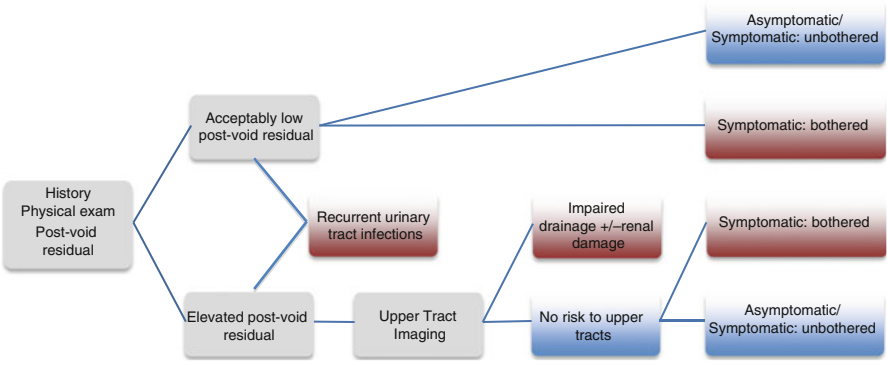

Fig. 13.3 Approach to incomplete bladder emptying

be unavoidable. Strict control of comorbidities and fluid management may assist in preventing progression of deteriorating function. The degree of bladder dysfunction from pharmacological causes varies based on the mechanism of action of the drug, as well as the metabolizing potential by the patient. There is no established time frame as to when the bladder may regain function. The patient should be treated with conservative therapies and/or catheterization with frequent assessment for return of detrusor function.

A number of oral drugs have been attempted to stimulate detrusor activity with no significant efficacy. These drugs include alpha-adrenergic antagonists, muscarinic receptor agonists (e.g., bethanechol), and prostaglandin E. Sacroneuromodulation has also been studied extensively in animal models, and emerging data in humans is demonstrating stimulation of sacral efferents and its modification on the reflex between bladder and urinary sphincter.

A number of investigational therapies are being studied, including gene therapy using nerve growth factor-encoded herpes simplex virus and stem cell therapy with muscle-derived cells from skeletal muscle, both of which are showing some promise in improving contractility and bladder emptying in rats. Nerve growth factor (NGF) is a neurotrophic protein that is necessary for normal function of sensory and sympathetic neurons and has been found to be protective of neurons from various neurotoxins. It has been extensively studied in animal models in being an important peptide for neurotrophic support for the lower urinary tract. It has been demonstrated that exogenous administration of NGF has a protective effect on diabetic rat bladders. Studies replacing NGF and other neuroprotective agents such as alpha-lipoic acid have showed promise.

Often in cases of patients with detrusor underactivity, even though it is not the primary cause, treatment is focused on the outlet (e.g., bladder neck incision or resection, urethral stricture repair or dilation, prostatectomy, transurethral resection, or sphincterotomy). The goal is to help promote emptying by reducing outlet resistance, even though resistance may not be "abnormal." It is critical that patients are counseled appropriately prior to performing any outlet procedure as there are risks associated with many of these procedures, and the procedures are not addressing the underlying etiology of their voiding dysfunction.

Bladder Outlet Dysfunction

Fixed Anatomic Obstruction In those with a fixed anatomic obstruction, there is high likelihood of improving emptying by removing the obstruction. With chronic long-standing obstruction, however, the detrusor also may have irrecoverable function. It is beneficial to have assessed for this prior to treatment for purposes of counseling, as well as appropriate treatment choices to offer the patient.

In men with obstructive or bothersome prostatic enlargement, management with medications is often the first course of action. In patients who fail medical therapy or which for surgical treatments, procedures to unobstruct the outlet can be

performed. These may be performed abdominally (prostatectomy) or transurethrally (transurethral resection of the prostate, greenlight vaporization, holmium laser enucleation). A recent meta-analysis comparing minimally invasive BPH management to traditional TURP found less improvement in symptom scores for patients that had transurethral needle ablation, laser coagulation, and transurethral microwave treatment than traditional transurethral resection of the prostate, although there was still overall a reduction in the IPSS by 3 points. Compared to TURP, these patients otherwise had less blood loss, lower stricture rate, and lower incontinence rates and were less likely to have loss of ejaculation. Laser coagulation, although shorter than TURP, had higher urinary retention rates and post-op UTI than the other treatment modalities. Transurethral needle ablation procedures were longer but had shorter hospital stays. Minimally invasive procedures had a higher need for reoperation.

Strictures may be dilated if short; however recurrent or long strictures may require a urethroplasty. Meatoplasty can be performed in those with meatal stenosis. Urethral carcinoma should be dealt with per oncology guidelines, which will be based on grading and depth of invasion and a number of patient factors.

Anatomic abnormalities in women may also require a procedure to treat, including repair of urethral diverticulum, caruncle, or prolapse, drainage of a Skene's gland abscess and removal of the cyst, and reduction of pelvic organ prolapse either with a pessary or with surgery. In those that have undergone anti-incontinence surgery, up to 30 % with an autologous sling may need to undergo sling lysis, 42 % with long-term catheterization, and urethal dilation in up to 8 %. Loosening or cutting of transvaginal tapes (TVTs) has found to have excellent results with restoration and normal voiding in almost all patients and marked improvement in storage and voiding symptoms. The rate of recurrent SUI after sling lysis is currently unknown.

Functional Obstruction Once a patient has been found to have a functional cause of obstruction, it is important to decipher which of the three causes they have, as the therapies vary for each other.

In those with primary bladder neck obstruction, alpha-blocker therapy is not unreasonable. It may act as both a diagnostic and therapeutic modality prior to proceeding with a transurethral incision of the bladder neck, which would be the next step.

In patients that have failure of the sphincter to relax, those with dysfunctional voiding may benefit from physical therapy and biofeedback in order to "relearn" how to void with proper coordination. Other therapies that have been implemented include Botox injections into the external urethral sphincter, sacroneuromodulation, and muscle relaxers. It may also benefit the patients to possibly undergo psychotherapy, especially in those with a history of abuse.

In patients with a neurological cause that prevents their sphincter from relaxing (DSD), one can also attempt botulinum toxin injections in the external urinary sphincter. Other options include sphincterotomy. The risks, however, of treating the outlet in patients with a neurological condition include making them incontinent. In some patients, it may be best to treat them with intermittent catheterization or, in

those with functional impairment, indwelling catheter (either transurethral or suprapubic) or a urinary diversion. A continent diversion may be considered in those that have good dexterity of their upper extremities and hands.

In patients diagnosed with Fowler's syndrome, the treatment of choice is sacroneuromodulation. Its postulated mechanism of action is retraining of the nerve input to the pelvic floor, which will allow its relaxation and thereby permitting the bladder to contract again.

Conclusion

Disorders of incomplete bladder emptying and urinary retention are in essence due to either failure of either the detrusor (detrusor underactivity) or of the outlet (bladder outlet obstruction). They are quite bothersome to a large population of patients and can cause additional concerns when contributing to recurrent urinary tract infections and/or upper tract deterioration. The diagnostic tests and treatments options are numerous; therefore it is important to approach these patients with a good understanding of possible causes and the roles for different tests. The gold standard study to determine the cause of incomplete emptying is urodynamics and should be utilized when there is not a clear etiology. Treatments for bladder outlet obstruction are numerous and should be offered after a complete and thorough assessment. Treatments for detrusor underactivity are unfortunately limited. Although there is promising research on a variety of investigational therapies, further work will be required to understand and treat this condition.

Point of Interest

- The physiology of voiding is intricate and complex, with a vast potential for disruption of normal voiding patterns.
- In order to properly empty, the bladder needs to generate a pressure of adequate strength and duration to overcome the resistance set by the outlet. Dysfunction of the bladder to generate the pressure needed or of the outlet to allow passage of urine results in incomplete bladder emptying.
- Underlying pathophysiological processes are important to understand as this may be a means for development of new therapies.
- It is important to have a common understanding of terminology applied to the genitourinary tract for purposes of reporting results and developing treatment guidelines.
- The workup is crucial to properly diagnose and to implement an effective treatment strategy. A thorough history and physical exam are then supplemented by studies, including post-void residual, uroflow, labs, imaging, and, the gold standard, urodynamics with our without fluoroscopy. Nomograms can be helpful to standardize the evaluation of

patients but are better served in men as there are not yet good criteria developed in women.
- Causes of bladder dysfunction are of neuropathic, myogenic, or pharmacologic etiologies. Of these three, only pharmacologic therapies are likely reversible. There is a role for sacroneuromodulation for acontractile detrusor.
- Causes of bladder outlet dysfunction are by either a fixed anatomic obstruction or a functional obstruction, the latter of which is from a failure of either the bladder neck or the sphincter and pelvic floor to relax. Treatment of bladder outlet dysfunction depends on the cause. Fixed anatomic obstruction can be surgically or medically treated. Primary bladder neck obstruction can have a trial of alpha-blocker or proceed to TUIBN. Dysfunctional voiding often involves "re-training" the bladder to void normally. Fowler's syndrome is treated with sacroneuromodulation.

Appendix 1: ICS 2002 Definitions of LUTS as They Pertain to Urinary Retention and Bladder-Emptying Disorders

International continence society subcommittee standardization of terminology in lower urinary tract function (2002)	
Terminology	**Definition**
Normal detrusor function	A voluntarily initiated continuous detrusor contraction that leads to complete bladder emptying within a normal time span and in the absence of obstruction. For a given detrusor contraction, the magnitude of the recorded pressure rise will depend on the degree of outlet resistance
Lower urinary tract symptoms (LUTS)	The subjective indicator of a disease or condition as perceived by the patient, caregiver, or partner that may lead him/her to seek help from healthcare professionals *Storage symptoms*: *frequency*, *nocturia*, *urgency*, *urinary incontinence* *Voiding symptoms*: *slow stream*, *splitting or spraying*, *intermittency*, *hesitancy*, *straining*, *terminal dribble* *Post micturition symptoms*: *feeling of incomplete emptying*, *post-micturition dribble*
Detrusor underactivity	A contraction of reduced strength and/or duration, resulting in prolonged bladder emptying and/or a failure to achieve complete bladder emptying within a normal time span
Acontractile detrusor	One that cannot be demonstrated to contract during urodynamic studies
Bladder outlet obstruction	The generic term for obstruction during voiding and is characterized by increased detrusor pressure and reduced urine flow rate. It is usually diagnosed by studying the synchronous values of flow rate and detrusor pressure *Further stated that bladder outlet dysfunction has been* "*defined for men but*, *as yet*, *not adequately in women and children*"

(continued)

Appendix 1 (continued)

Dysfunctional voiding	Voiding characterized by an intermittent and/or fluctuating flow rate due to involuntary intermittent contractions of the periurethral striated muscle during voiding in neurologically normal individuals *It has also be termed* "*non-neurogenic neurogenic bladder*," "*idiopathic detrusor sphincter dyssynergia*," *or* "*sphincter overactivity voiding dysfunction*"
Detrusor sphincter dyssynergia	A detrusor contraction concurrent with an involuntary contraction of the urethral and/or periurethral striated muscle. Occasionally, flow may be prevented altogether *Occurs in patients with a supra-sacral lesion and is uncommon in lesions of the lower cord*
Non-relaxing urethral sphincter obstruction	Usually occurs in individuals with a neurological lesion and is characterized by a non-relaxing, obstructing urethra resulting in reduced urine flow *Found in sacral and infra-sacral lesions. This term replaces* "*isolated distal sphincter obstruction*"
Acute retention of urine	A painful, palpable, or percussible bladder, when the patient is unable to pass any urine *In certain circumstances pain may not be a presenting feature* (*herniated vertebral disk*, *post-anesthesia*, *postpartum*)
Chronic retention of urine	A non-painful bladder, which remains palpable or percussible after the patient has passed urine. Such patients may be incontinent *Implies a significant residual urine* (*a minimum figure of 300 mL has been previously mentioned in men*)
Benign prostatic obstruction	A form of *bladder outlet obstruction* and may be diagnosed when the cause of outlet obstruction is known to be benign prostatic enlargement, due to histologic benign prostatic hyperplasia
Benign prostatic hyperplasia	A term used (and reserved) for the typical histological pattern which defines the disease
Benign prostatic enlargement	Prostatic enlargement due to histologic benign prostatic hyperplasia *The term* "*prostatic enlargement*" *should be used in the absence of prostatic histology*

Further Reading

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